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## The Genus *Viviparus* (Viviparidae) in North America<sup>1</sup>

By WILLIAM J. CLENCH AND SAMUEL L. H. FULLER<sup>2</sup>

The North American species of *Viviparus* can easily be distinguished on the basis of shell morphology. The confusion centered about the taxonomic status of *V. georgianus* (Lea) and a host of synonymous names and forms has been previously discussed (Clench 1962a). This report distinguishes between this species and five additional species endemic in North America. One species is restricted to Cuba and two others are distinctive oriental introductions.

The genera *Tulotoma*, *Lioplax* and *Campeloma* comprise the viviparid genera which are endemic to North America. The genus *Lioplax* Troschel has been monographed (Clench and Turner, 1955). *Viviparus* (s.l.) is widely distributed throughout much of the world, except Central and South America, though it occurred in the mid-Tertiary in Argentina.

According to Prashad (1928), a number of fossil and possibly ancestral viviparids are to be found in North America. These are chiefly from the Laramie beds of the West which extend from New Mexico through the Rocky Mountain region into northern Alberta in a vast series of deposits variously considered to be of Cretaceous or Jurassic age. Prashad cites *Viviparus gillianus* [gilli] Meek and Hayden (probably Jurassic) as the ancestor from which rose modern *Lioplax*, possibly

<sup>1</sup> Publication costs supported in part by the Milton Fund, Harvard University.

<sup>2</sup> Harvard undergraduate student.

*Campeloma*, and the Recent North American forms of *Viviparus*. He considers modern *Viviparus* to be of fourfold polyphyletic origin, with the Laramie forms representing the ancestral locus on this continent. He points out that we have no extinct forms from any of the areas where in the past there might conceivably have once been a land connection between North America and other continents; that the fossil record is barren of viviparids from Mexico and Central America, Alaska, and Eastern Canada. Given our scanty knowledge of the fossils of these areas, these facts are hardly evidence that North American viviparids evolved independently from those of Europe, Asia, Africa and South America. Moreover, the degree of convergence necessary for Prashad's four viviparid groups to have arisen independently is virtually impossible.

The existing evidence that North American fossil viviparids are among the earliest known for the family indicates an origin of the Viviparidae, possibly in some area other than this continent. The oldest of our fossil forms examined by Prashad were in an advanced state of differentiation, which could argue equally that North America *might* be the original viviparid locus, or that the Viviparidae might have reached the Laramie region from elsewhere in this highly evolved state. Lack of information renders the whole question equivocal at best, but we do feel that it is erroneous to postulate a polyphyletic origin for the Viviparidae.

The distribution of the Recent Viviparidae is another matter. Certainly the present North American fauna has arisen independent of any influence from other regions, with the exception of the two introductions mentioned previously. The genera *Viviparus* and *Lioplax* have begun to reinvade glaciated areas to any extent only during the past century (Clench and Turner, 1955; Clench, 1962a).

The development since the days of the Laramie beds of fluviatile connections between the Missouri and eastern river drainages would account for the recent expansion and modest proliferation of *Viviparus* east of the Mississippi River. Today the genus is found from the Sabine River in eastern Texas, throughout the rivers of the Gulf States, and in virtually every river system north along the Atlantic coast to the St. Lawrence River. *Campeloma* has an even wider distribution in

eastern North America, reaching as far north as Red Lake, Ontario, in the Hudson Bay Drainage. *Tulotoma* is restricted to the Alabama-Coosa River System, and *Lioplax* has evolved four related but distinguishable species in closely delimited ranges east of the Mississippi River (see Clench and Turner, 1955; Clench, 1962b).

The basis for this vast modern distribution is ecological; viviparids have an extraordinary tolerance of and adaptability to new and demanding environments. Certainly *Campeloma* is most tolerant, but *Viviparus* itself is almost equally so. Members of this latter genus, especially *V. georgianus* and, in some cases, *V. intertextus*, may occur under the most adverse conditions in water fouled by silting and pollution. *Viviparus* prefers a mud and detritus substrate in nearly stagnant to moderately flowing water, usually in areas with some protective vegetation. The majority of North American species are essentially southern, reflecting a predilection for warmer waters. They exhibit great morphological plasticity (see Pl. 64, figs. 1-12).

#### ACKNOWLEDGMENTS

The authors are much obliged to several curators and others for advice, information, and the loan of material for the study of this genus. They are R. T. Abbott, Leslie Hubricht, H. A. Rehder and Juan Parodiz. We are indebted additionally to our colleague, Ruth D. Turner, for reading the manuscript and for aid in several other ways. Finally, we are grateful to C. O. van Regteren Altena for photographs of material in the Leiden Museum.

#### ABBREVIATIONS

ANSP	Academy of Natural Sciences of Philadelphia
MCZ	Museum of Comparative Zoology
RVNH	Rijksmuseum van Natuurlijke Historie, Leiden

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### ***Viviparus subpurpureus* (Say)**

Plate 65, figs. 5-8; Plate 67

*Paludina subpurpurea* Say 1829, New Harmony Disseminator of Useful Knowledge 2:245 (Fox River, an arm of the Wabash [White Co., Illinois]). [Holotype lost.]

*Vivipara texana* Tryon 1862, Proc. Acad. Nat. Sci. Philadelphia, p. 451 (Texas). [Holotype, ANSP 27714a; paratypes MCZ 25064.]

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## Plate 64

All are *Viviparus georgianus* (Lea)

- Fig. 1. Wekiva River, 15 miles NW of Winter Park, Seminole Co., Florida (1.8×).
- Fig. 2. *Paludina georgiana* Lea (= *Viviparus georgianus* (Lea)). Altamaha River, Hopeton, near Darien [McIntosh Co.], Georgia. Syntype, MCZ 186792 (1.9×).
- Fig. 3. Canal, Utica, La Salle Co., Illinois (1.2×).
- Fig. 4. Lake Monroe, Seminole Co., Florida (1.8×).
- Fig. 5. Decatur, Morgan Co., Alabama (1.2×).
- Fig. 6. *Vivipara inornata* Binney (= *Viviparus georgianus* (Lea)). Near Chapatilo, Mexico [northern Florida?]. Lectotype, MCZ 234704 (1.8×).
- Fig. 7. Chesapeake and Ohio Railroad canal, above Violets Lock, Seneca, Montgomery Co., Maryland (1.9×).
- Fig. 8. Lake Talquin, Leon Co., Florida (1.8×).
- Fig. 9. Steinhatchee River, 9 miles E of Salem, Taylor Co., Florida (1.9×).
- Fig. 10. Kiokee Creek, 15 miles SE of Dawson, Terrell Co., Georgia (1.9×).
- Fig. 11. St. Lawrence River, S of Ile d'Orlean, St. Michel, Bellechasse Co., Quebec, Canada (1.8×).
- Fig. 12. Silver Springs, near Silver Springs, Marion Co., Florida (1.9×).

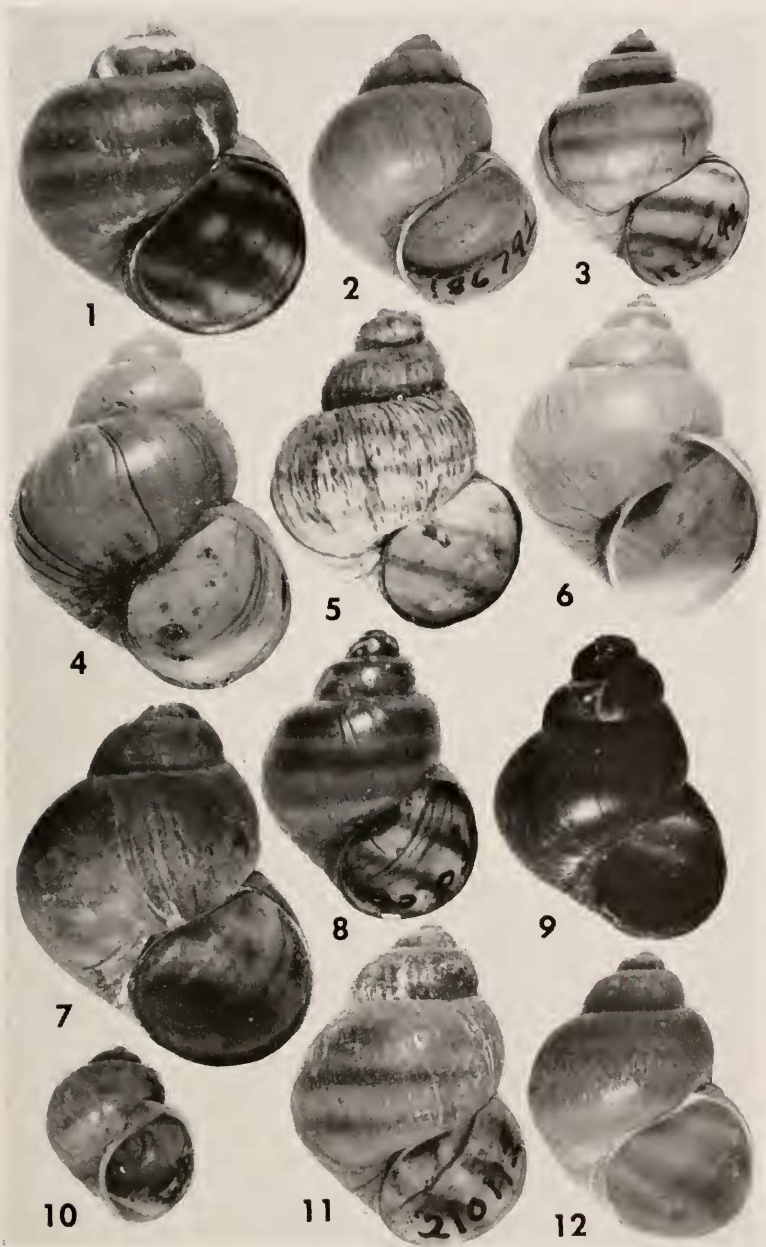


Plate 64

*Description.* Shell subglobose to attenuate in outline and varying in size, large specimens reaching about 33 mm. (about  $1\frac{1}{2}$  inches) in length, imperforate or with a narrow, slit-like umbilicus. Usually rather heavy in structure, strong and smooth. Color yellowish or olivaceous brown. Color bands, when present, are typically of brownish color, three in number and generally evenly spaced. Whorls 5 to  $6\frac{1}{2}$ , moderately convex and occasionally with a slight shoulder. Spire extended and produced at an angle of about  $45^{\circ}$  to  $55^{\circ}$ . Aperture sub-circular. Outer lip thin. Parietal lip consisting of a thickened glaze. Columella narrow and arched. Suture deeply indented. Sculpture consisting of fine growth lines, with some specimens showing exceedingly fine spiral threads, and occasionally with faint malleations. Operculum corneous, thin, with concentric growth lines and a submarginal nucleus.

length	width	
33.0 mm.	21.5 mm.	Mississippi River, Vicksburg, Warren Co., Mississippi
24.0	18.0	Kaskaskia River, 2 mi. W of Baldwin, Randolph Co., Illinois
23.0	16.5	Neches River, Town Bluff, Tyler Co., Texas
27.5	20.0	Wabash River, New Harmony, Posey Co., Indiana

*Remarks.* So far as we can determine, all of the characters given by Tryon for *Vivipara texana* are found among populations throughout the range of *Viviparus subpurpureus* and thus possess no geographic significance.

The range of *V. subpurpureus* is confined mainly to the Mississippi River System and a few small systems in eastern Texas and western Mississippi. This distribution overlaps in part with that of *V. intertextus* Say, but there is absolutely no resemblance between the two forms. We have sexed material of *V. subpurpureus* received through the kindness of Leslie Hubricht and these show that there can be pronounced sexual dimorphism in this species; female specimens being much larger than males. It is ordinarily the smaller male individuals in a given population which exhibit the squat and somewhat twisted features to be seen in Plate 65, figs. 6 and 8. Larger and less twisted specimens may closely resemble certain specimens from the presumably depauperate populations of *V.*

*georgianus* Lea in the middle and southern portions of Florida (compare Plate 65, fig. 5 with Plate 64, figs. 4 and 11). However, individuals of the latter species will always be much lighter in structure, are more likely to have spiral bands of color as well as fewer whorls. Individuals of *V. subpurpureus* may commonly have only three bands while *V. georgianus* generally has four bands.

*Viviparus subpurpureus*, like *intertextus* are often found on rocky substrates in swift water, a rather atypical habitat for species in this genus.

*Specimens examined.* NECHES RIVER SYSTEM. TEXAS: Neches River,  $\frac{1}{2}$  mi. below dam, Town Bluff, Tyler Co. and Evadale, Jasper Co. (both MCZ). SABINE RIVER SYSTEM. TEXAS: Sabine River, Smith's Fish Camp, 1 mi. N of Deweyville; confluence of Sabine River and Cypress Creek, 5 mi. N of Deweyville, both Newton Co. (both MCZ). LOUISIANA: Sabine River, 18 mi. SW of Many, Sabine Parish (MCZ). ATCHAFALAYA RIVER SYSTEM. LOUISIANA: Arm of the Atchafalaya River, 10 mi. SE of LeBeau, St. Landry Parish (MCZ). MISSISSIPPI RIVER SYSTEM. MISSISSIPPI RIVER DRAINAGE. LOUISIANA: University Lake, Louisiana State University, Baton Rouge, East Baton Rouge Parish (MCZ); Lake Concordia, Concordia Parish (L. Hubricht; MCZ). MISSISSIPPI: Big Black River, 3 mi. NW of Edwards, Hinds Co. (L. Hubricht; MCZ); Mississippi River; Yazoo River, both Vicksburg, Warren Co.; Natchez, Adams Co. (all MCZ). ARKANSAS: Grand Lake, Chicot Co. (MCZ). ILLINOIS: Mississippi River, Nauvoo, Hancock Co. and Mercer Co. (both MCZ). IOWA: Mississippi River, Davenport, Scott Co.; above McGregor, Clayton Co. (both MCZ). RED RIVER DRAINAGE. LOUISIANA: Saline Bayou at U.S. 84, east of Clarence, Natchitoches Parish; canal, 6.5 mi. W of Krotz Springs, St. Landry Parish; Tensas River; Tendal, Madison Parish (all L. Hubricht; MCZ); Black River, Jonesville; Lake St. John, 9 mi. NE of Ferriday, both Concordia Parish; Old River, 8 mi. SE of Jena, LaSalle Parish (all H. D. Athearn; MCZ); outlet, Lake Catahoula; Little River, both 1 mi. SW of Archie, Catahoula Parish; Ouachita River, near Columbia, Caldwell Parish; Lake Bisteneau, Bienville Parish; Bayou Pierre, Frierson's Mills, DeSoto Parish (all MCZ). TEXAS: Caddo Lake, Harrison Co.

(MCZ). ARKANSAS: Bartholomew Bayou, near Jerome, Drew Co. (MCZ). OKLAHOMA: Little River, 6 mi. NE of Idabel, McCurtain Co. (L. Hubricht; MCZ). WHITE RIVER DRAINAGE. ARKANSAS: Indian Bay, near Baytown, Monroe Co.; Caches River (both MCZ). ST. FRANCIS RIVER DRAINAGE. ARKANSAS: St. Francis River, Wittsburg, Cross Co. (MCZ). OHIO RIVER DRAINAGE. INDIANA: Wabash River, Grand Chains Rapids below New Harmony, Posey Co. (MCZ). ILLINOIS: Ohio River, Elizabethtown, Hardin Co.; Wabash River, Mt. Carmel, Wabash Co.; Little Wabash River, Carmi, White Co.; Saline River, Saline Mines, Gallatin Co. (all MCZ). KENTUCKY: Kentucky River, Gratz, Owen Co.; Tradewater River, Belleville, Webster Co. (both MCZ). ILLINOIS RIVER DRAINAGE. ILLINOIS: Illinois River (MCZ). KASKASKIA RIVER DRAINAGE. ILLINOIS: Kaskaskia River, New Athens, St. Clair Co., 2 mi. W of Baldwin, Randolph Co. (both L. Hubricht; MCZ). PASCAGOULA RIVER SYSTEM. MISSISSIPPI: Pascagoula River, Merrill, George Co. and 6 mi. W of Wade, Jackson Co. (both L. Hubricht; MCZ).

### ***Viviparus intertextus* (Say)**

Plate 65, figs. 2-3; Plate 68

*Paludina intertextus* Say 1829, New Harmony Disseminator of Useful Knowledge 2:244 (marshes near New Orleans and on bank of Carondelet Canal, Louisiana). [Lectotype, ANSP 124545.]

*Paludina transversa* Say 1829, New Harmony Disseminator of Useful Knowledge 2:244 (near New Orleans). [Types lost.]

*Paludina troostiana* Lea 1841, Proc. American Phil. Soc. 2:34 (Tennessee); 1844, Trans. American Phil. Soc. 9:14; 1848, Observations on the Genus Unio 4:14. [Lectotype, USNM 121119.]

*Paludina haleiana* Lea 1845, Proc. American Phil. Soc. 4:167; 1848, Trans. American Phil. Soc. 10:96, pl. 9, fig. 58; 1848, Observations on the Genus Unio 4:70, pl. 9, fig. 58 (Alexandria, Louisiana). [Lectotype, USNM 106256.]

*Viviparus haleanus* 'Lea' Walker 1918, Mus. of Zool., Univ. of Michigan, Misc. Publications no. 6, p. 125. [Error for *V. haleianus* Lea.]

*Viviparus intertextus illinoisensis* Baker 1928, Wisconsin Geological and Natural History Survey, Bull. 70, pt. 1, p. 38, pl. 2, figs. 18-21 (Illinois River, Havana [Mason Co.], Illinois). [Holotype, Univ. of Illinois Z18025.]

*Description.* Shell ranging from globose to depressed globose and varying somewhat in size, large specimens reaching about 32 mm. in length. Imperforate or with a narrow, slit-like to circular umbilicus. Rather thin in structure and smooth.



Color dark yellowish green to dark olivaceous green. All examined mature specimens totally lacking bands; occasional immature individuals with three reddish bands, possibly a fourth indistinct band. Whorls usually  $4\frac{1}{2}$ , strongly convex and with a slight shoulder. Spire moderately extended and produced at an angle of about  $55^\circ$  to  $80^\circ$ . Aperture subovate. Outer lip thin and generally with a blackened margin extending shortly within. Inner lip also margined with black, and with the parietal area somewhat thickened. Columella narrow and arched. Suture deeply indented. Sculpture consisting of fine axial growth lines and minutely beaded spiral threads. Operculum corneous, thin, with concentric growth lines and a depressed submarginal nucleus.

length	width	
23.0 mm.	22.5 mm.	New Orleans, Orleans Parish, Louisiana
32.0	28.0	pond, 13 mi. W of Houston, Harris Co., Texas
26.0	24.0	Winnebago Co., Illinois
27.0	24.0	White Bear Lake, Ramsey Co., Minnesota
26.5	22.0	" " " " " "

*Remarks.* *Viviparus intertextus* has a rather unusual distribution as shown on Plate 68. This is possibly a reflection of the ecology of the animals and the recent trend of various species of North American *Viviparus* to extend their ranges to the north. At present there is no satisfactory explanation for its occurrence in eastern Georgia and South Carolina.

This species is usually found around and among the roots and stems of underwater vegetation in cool and comparatively swift water. The substrate is generally of a coarser nature than that tolerated by other North American species in this genus, being gravelly and stony with an admixture of sand. Sometimes the streams in which they are found are no more than a yard or two in width, and we have found specimens in areas where they must be exposed to rather thorough scouring when the streams are in flood.

Baker (1928) distinguished his *Viviparus intertextus illinoisensis* from the typical form on the basis of the fact that "typical *intertextus* has a very wide, somewhat globular shell with a broadly depressed spire, the nuclear whorls of which are coiled in the same plane, while in *illinoisensis* the shell is subglobose, the spire rather elevated, the spire whorls being

## Plate 65

- Fig. 1. *Viviparus georgianus* (Lea). Stone's River, 7 miles NNE of Murfreesboro, Rutherford Co., Tennessee (1.9×).
- Fig. 2. *V. intertextus* (Say). Cedar River, Cedar Rapids, Lynn Co., Iowa (1.9×).
- Fig. 3. *V. intertextus* (Say). Little Ohoopsee River, 2 miles N of Kite, Johnson Co., Georgia (1.9×).
- Fig. 4. *V. georgianus* (Lea). Chipola River, 5.5 miles W of Greenwood, Jackson Co., Florida (1.2×).
- Fig. 5. *V. subpurpureus* (Say). Mississippi River, Vicksburg, Warren Co., Mississippi (1.8×).
- Fig. 6. *V. subpurpureus* (Say). [St. Francis River], Wittsburg, Cross Co., Arkansas (1.8×).
- Fig. 7. *V. subpurpureus* (Say). Kentucky River, Gratz, Owen Co., Kentucky (1.8×).
- Fig. 8. *V. subpurpureus* (Say). Outlet, Lake Catahoula, 1 mile SW of Archie, Catahoula Parish, Louisiana (1.8×).

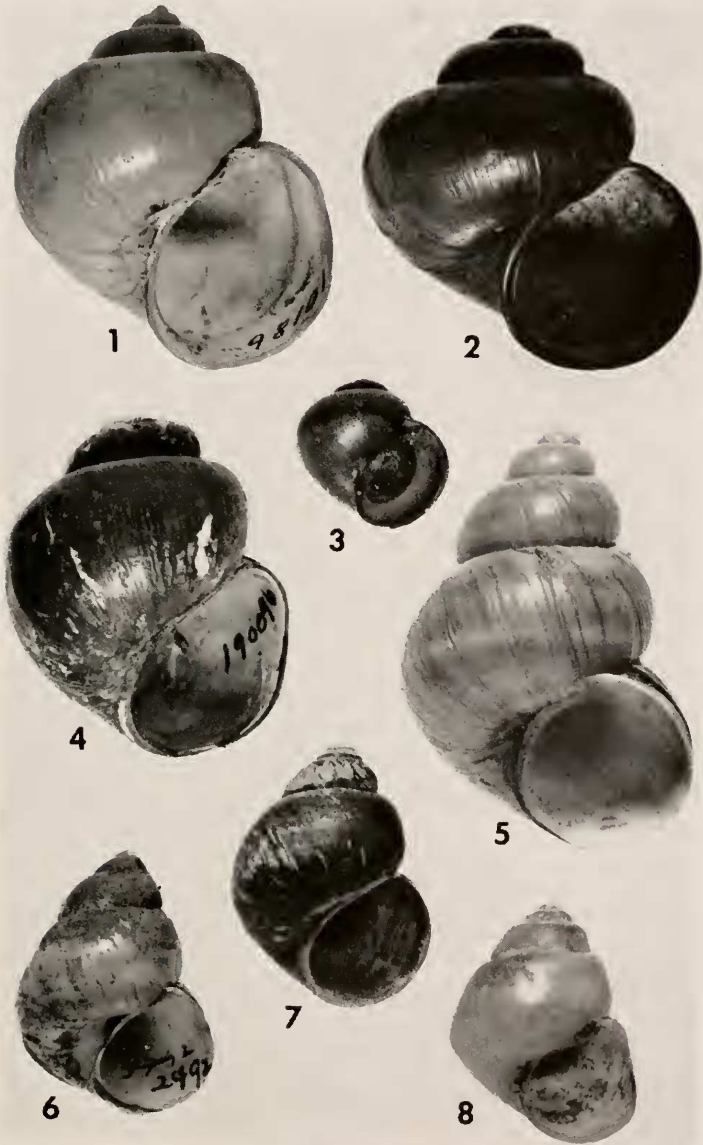


Plate 65

more regularly descending, and the sutures are more deeply impressed." This statement is true only in part, as all of the characters mentioned are variable, and any one population will have specimens transitional between these two 'subspecies'. On the whole, the northern populations tend to be a little more openly umbilicate, but even this character is variable and does not separate the two forms.

Some specimens of *intertextus* closely resemble *V. georgianus* Lea, but adult specimens can, so far as we know, always be distinguished by the complete lack of banding in *intertextus*, its depressed spire and lighter structure.

*Specimens examined.* HOUSTON SHIP CHANNEL SYSTEM. TEXAS: Addicks; 13 mi. W of Houston, both Harris Co. (both MCZ). SAN JACINTO RIVER SYSTEM. TEXAS: Cleveland, Liberty Co. (MCZ). LIBERTY RIVER SYSTEM. TEXAS: Dayton, Liberty Co. (MCZ). NECHES RIVER SYSTEM. TEXAS: Neches River, Town Bluff, Tyler Co. (MCZ). BAYOU TECHE SYSTEM. LOUISIANA: Bayou Teche, near St. Martinville, St. Martin Parish; Grand Coteau, St. Landry Parish (both MCZ). MISSISSIPPI RIVER SYSTEM. MISSISSIPPI RIVER DRAINAGE. LOUISIANA: New Orleans, Orleans Parish (MCZ); Harahan, Jefferson Parish; near Houma, Terrebonne Parish (both USNM). ARKANSAS: L'Anguille River, St. Francis Co. (ANSP). TENNESSEE: Samburg, Obion Co. (MCZ). ILLINOIS: Warsaw, Hancock Co.; Glancy's Lake, Mercer Co.; Rock Island, Rock Island Co. (all MCZ); Lake Harmon (USNM); Rockford (MCZ), both Winnebago Co. IOWA: Burlington, Des Moines Co.; Muscatine, Muscatine Co. (both MCZ); Davenport, Scott Co. (USNM; ANSP). MINNESOTA: Minneapolis, Hennepin Co. (USNM); White Bear Lake, Ramsey Co. (MCZ). RED RIVER DRAINAGE. LOUISIANA: Bayou Boeuf, Richland Parish; Ouachita River, Alabama Landing, Union Parish (both ANSP); Alexandria, Rapides Parish (USNM); Frierson, DoSoto Parish (MCZ); Shreveport, Caddo Parish (USNM). WABASH RIVER DRAINAGE. ILLINOIS: Wabash River, Mt. Carmel, Wabash Co. (ANSP). ILLINOIS RIVER DRAINAGE. ILLINOIS: Havana, Mason Co. (ANSP); Canton, Fulton Co. (MCZ); Putnam Co. (ANSP); Joliet, Will Co. (USNM). IOWA RIVER DRAINAGE. IOWA: Cedar River, Cedar Rapids, Linn Co. (MCZ); Waterloo,

Blackhawk Co. (USNM). PEARL RIVER SYSTEM. MISSISSIPPI: Conway's Slough, Jackson, Hinds Co. (MCZ). COOSA-ALABAMA RIVER SYSTEM. ALABAMA: Alabama River, Halley's Landing, E of Pine Hill, Wilcox Co. (ANSP; USNM); floodplain, Tombigbee River, Jackson, Clarke Co. (ANSP). ALTAMAHA RIVER SYSTEM. GEORGIA: Ohoopce River, Wrightsville; Little Ohoopce River, Kite, both Johnson Co.; Alligator Creek, 10 mi. S of Rentz, Laurens Co.; Gum Swamp Creek, McRae, Telfair Co. (all MCZ). EDISTO RIVER SYSTEM. SOUTH CAROLINA: Summerville, Dorchester Co. (MCZ). SANTEE RIVER SYSTEM. SOUTH CAROLINA: Pocotaligo River, Manning; Clarendon Co.; Santee Canal, Berkeley Co. (both ANSP). GREAT LAKES-ST. LAWRENCE RIVER SYSTEM. LAKE SUPERIOR DRAINAGE. MINNESOTA: Rainy Lake at Rainy Lake, Koochiching Co. (ANSP).

### *Viviparus georgianus* Lea

Plate 64, figs. 1-12; Plate 65, figs. 1, 4

*Lymnaea vivipara* 'Linnaeus' Say 1817, Nicholson's Encyclopedia 2:17, pl. 2, fig. 5 (no locality given); non Linnaeus 1758.

*Paludina georgiana* Lea 1834, Trans. American Philosophical Soc. (n.s.) 5: 116, pl. 19, fig. 85 (Hopeton, near Darien, [McIntosh Co.], Georgia).<sup>1</sup> [Holotype, USNM 106252; paratype, MCZ 186792.]

*Paludina linearis* 'Valenciennes' Küster 1852, Conchylien-Cabinet (2) 1 (pt. 21):19, pl. 4, fig. 4 (Simpson Creek Lake, East Florida).

*Paludina wareana* 'Shuttleworth' Küster 1852, Conchylien-Cabinet (2) 1:(pt. 21), pl. 4, figs. 10-11 (Ostflorida in Ware-See [Lake Weir, Marion Co., Florida]).

*Vivipara haldemanniana* 'Shuttleworth' Frauenfeld 1862, Verh. K. K. Zool. Bot. Gesell. Wien, p. 1162 (Black Creek [Clay Co.], East Florida).

*Vivipara inornata* Binney 1865, American Jour. of Conchology 1:49, pl. 7, fig. 1 (near Chopatilo, Mexico). [Lectotype, MCZ 234704; paratype, MCZ 20512.]

*Vivipara contectoides* Binney 1865, Smithsonian Misc. Collections, no. 144, pt. 3, p. 23, text figs. 41-44 (Florida). [Lectotype, MCZ 74393; paratypes, USNM 27756.]

*Vivipara georgiana fasciata* Tryon 1870, Monograph of the Freshwater Univalve Mollusca of the United States, Philadelphia, p. 17 (no locality given [Florida]). [Types lost.]

*Paludina inornata* Binney [in] Fischer and Crosse 1890, Mission Scientifique au Mexico et dans l'Amerique Centrale 2:291. [Lectotype, MCZ 234704; paratypes, USNM 9168.]

<sup>1</sup> Hopeton, or Hopeton's Landing, was about 10 to 15 miles up the Altamaha River from Darien, McIntosh Co., Georgia. This was a plantation landing, and, like many others, was used when the larger rivers were the main source of transportation. Most place names of this type have long since disappeared.

*Vivipara georgiana altior* Pilsbry 1892, *Nautilus* 5:142 (aboriginal shell heap, left bank of Hitchen's Creek, near entrance of St. Johns River into Lake George [Putnam Co.], Florida). [Lectotype, ANSP 63420a.]

*Viviparus georgiana limnothauma* Pilsbry 1895, *Nautilus* 8:116 (aboriginal shell-field, Hitchen's Creek [near entrance of St. Johns River into Lake George, Putnam Co.], Florida and in 2 fathoms, Lake George [Florida]). [Lectotype, ANSP 70052a.]

*Viviparus walkeri* Pilsbry and Johnson 1912, *Nautilus* 26:48, pl. 3, figs. 6-7 (Juniper Creek, Lake Co., Florida). [Lectotype, ANSP 70053a.]

*Viviparus contectoides impolitus* Pilsbry 1916, *Nautilus* 30:41 (in marsh, Paint Rock River, Jackson Co., Alabama). [Holotype, ANSP 66701a.]

*Viviparus contectoides compactus* Pilsbry 1916, *Nautilus* 30:42 (Dougherty, [Co.?], Georgia). [Holotype, ANSP 27731]; non *compactus* Kobelt 1906.

*Viviparus contectoides limi* Pilsbry 1918, *Nautilus* 32:71 (Dougherty, [Co.?], Georgia). [Holotype, ANSP 27731]; [new name for *V. compactus* Pils.; non Kobelt].

*Viviparus contectoides goodrichi* Archer 1933, *Nautilus* 47:19, pl. 3, figs. 1-3 (spring-fed stream, tributary of the Chipola River, 5 mi. NE of Marianna, Jackson Co., Florida). [Holotype, MCZ 92432.]

*Description.* Shell subglobose in outline and varying in size, large specimens reaching about 44 mm. (about  $1\frac{3}{4}$  inches) in length, imperforate or with a narrow, slit-like umbilicus. Usually rather thin in structure, but strong and smooth. Color yellowish or olivaceous green to dark brownish green, banded or uniform in color. Banded specimens usually have four dark, reddish brown bands, fairly evenly spaced. Whorls 4 to 5, strongly convex and generally with a slight shoulder. Spire somewhat extended and produced at an angle of from  $50^{\circ}$  to  $65^{\circ}$ . Aperture ovate to subcircular. Outer lip thin, parietal lip consisting of a thickened glaze. Columella narrow and arched. Suture deeply indented. Sculpture consisting only of fine growth lines. Young specimens with a few spiral threads which eventually disappear as they grow older. Operculum corneous, thin, with concentric growth lines and a submarginal nucleus.

length	width	
44.0 mm.	35.0 mm.	Holotype, <i>V. C. goodrichi</i> Archer
26.0	19.5	Holotype, <i>V. georgianus</i> Lea
25.0	21.0	Lectotype, <i>V. c. limi</i> Pilsbry
33.0	21.5	Lectotype, <i>V. contectoides</i> Binney

*Remarks.* *Viviparus inornatus* Binney is here considered a tentative synonym of *georgianus* because it very closely re-

sembles certain atypical green and unbanded specimens of *georgianus* found in otherwise normally banded populations from northern Florida. It is our contention that the locality given for Binney's specimens was in error because we have been unable to find "Chopatilo", Mexico on any map, old or new, and because (with the exception of a few recent records for *V. subpurpureus* Say in small rivers of eastern Texas) no *Viviparus* has been known from west of the Mississippi River System. The genus has been recorded in the fossil from the Lower Cretaceous of Alberta, Canada, and the Upper Cretaceous from Utah, and the Eocene from Utah and Washington. In areas in the central and eastern states, all within the present range of this genus, the fossil history dates from the Lower Cretaceous. (See Henderson, 1935, pp. 14-15.)

Clench and Turner (1956) considered *V. georgianus wareanus* Küster as a questionable subspecies, but additional material from south-central Florida has shown that there is no basis for this separation. Specimens from this area are usually smaller than those in the more northern populations, but small specimens do occur throughout the range of the species.

For a discussion of the habitat, range and distribution records of *V. georgianus*, see Clench, this volume, pp. 262-271.

### ***Viviparus bermondianus* d'Orbigny**

Plate 66, fig. 5

*Paludina bermondiana* d'Orbigny 1842 [in] Ramon de la Sagra, Hist. de l'Ile de Cuba, Mollusques 2:7, pl. 10, fig. 5 (Cuba [Rio Hanábana, Ciénega Oriental de Zapata, Las Villas Province]). [Types in the British Museum (Nat. Hist.).]

*Description.* Shell subglobose in outline and varying considerably in size, large specimens reaching about 17 mm. (about  $\frac{5}{8}$  inch) in length, with a wide circular or oval umbilicus and a pronounced depression. Shell thin in structure, strong and smooth. Color olivaceous, usually stained in browns and banded. Bands three in number, brown, and rather evenly spaced, the uppermost one situated at the suture. Whorls 4 to 5, strongly convex, and rarely with a moderate shoulder. Spire somewhat elevated and produced at an angle of about 85° to 110°. Aperture ovate. Outer lip thin and strong. Parietal lip consisting of a thickened glaze. Columella narrow and

arched. Suture deeply indented. Sculpture consisting only of fine growth lines. Operculum corneous, thin, with concentric growth lines and a somewhat indented submarginal nucleus.

length	width	
17.0 mm.	15.0 mm.	San Francisco, Ciénega de Zapata, Las Villas Province, Cuba
17.0	14.0	Rio Hanábana, Ciénega Oriental de Zapata, Las Villas, Cuba
9.0	8.0	“ “ “ “

*Remarks.* This species is limited to the region of the Ciénega de Zapata, a great swamp on the Zapata Peninsula, Las Villas Province, Cuba. It is a very distinct species, characterized by a large and consistent umbilicus with a depression or embayment around it, and by the presence of three spiral bands of brown. The species appears closely related to *V. georgianus* Lea and *V. intertextus* Say. The consistent three banded color pattern of *V. bermondianus* distinguishes it from *intertextus*, which ordinarily has none and from *V. georgianus*, which ordinarily has four.

*Viviparus bermondianus* is apparently a rare species, for though known for over a century, specimens are still extremely rare in collections. It is strange that this species is so limited in distribution; and moreover, its presence in Cuba as the only Caribbean species of *Viviparus* is difficult to explain.

*Specimens examined.* CUBA: Rio Hanábana, Ciénega Oriental de Zapata, Las Villas Province; San Francisco, Ciénega de Zapata (we have been unable to locate "San Francisco"; if it is a region or a town, we are still unable to verify the province) (both MCZ).

### Subgenus *Cipangopaludina Hannibal*

*Cipangopaludina Hannibal* 1912, Proc. Malac. Soc. London **10**:194 (type species, *Paludina mallcata* Reeve, original designation).

*Lecythoconcha Annandale* 1920, Records of the Indian Mus. **19**:111, text fig 1 (type species, *Paludina lecythis* Benson, monotypic); Annandale 1921, Mem. Asiatic Soc. Bengal **6**:401.

When Annandale first introduced his genus *Lecythoconcha* he stated "An examination of the animal of Benson's *Paludina lecythis* proves that it and its allies must be separated from



*Vivipara*. I propose for them the new generic name *Lecythoconcha*." In his second reference given above he gives "its allies" as *malleata* Reeve, *sclateri* Frauen. and *japonica* v. Mts.

The shell is generally large, broad and with an elevated spire. The young, and frequently the adults of certain species, have one to four spiral, thread-like lines which support short periostracal hairs. Other sculptural features exhibited by species in this subgenus are in the form of malleations and fine carinae. According to Annandale (1920) the mantle differs from *Viviparus* s.s. in the greatly thickened and very muscular free edge.

We have made no attempt to work out the synonymy of the two following Oriental introductions in North America. The most recent study known to us is that of T.-C. Yen (1939) which covers only China. The range of *V. chinensis malleatus* (Reeve) extends at least as far as Japan.

***Viviparus (Chipangopaludina) japonicus* von Martens**  
Plate 66, figs. 3-4, 6-7

*Paludina japonica* von Martens 1861, Malakozoologische Blätter 7:44 (no locality given, but there is mention of typical specimens of the same species, "also from Japan"). [Lectotype, Leiden Mus. 50149, here selected.]

*Description*. Shell somewhat extended, varying in size, large specimens reaching 65 mm. (about 2½ inches) in length. Rimately umbilicate. Rather thin in structure, strong and smooth. Color olivaceous green to dark brownish green, without banding. Whorls 7 to 8, strongly convex, with a smoothly rounded shoulder and a moderate carina below the suture, often with faint carinae both above and below the periphery. Spire extended and produced at an angle of some 50° to 55°. Aperture subovate. Outer lip thin. Parietal lip consisting of a thin glaze. Columella narrow and arched. Suture deeply indented. Sculpture of fine to coarse growth lines and a few fine spiral threads. Many specimens exhibit faint malleations, particularly on the earlier whorls. Operculum corneous, thin, with concentric growth lines and a submarginal nucleus.

length	width	
65.0 mm.	40.0 mm.	Lake Biwa, Japan
62.0	41.0	Koriyama, Japan
53.0	31.0	Spark's Park, Jackson, Jackson Co., Michigan
42.0	30.5	Concord River, Concord, Middlesex Co., Massachusetts

## Plate 66

- Fig. 1. *Viviparus malleatus* Reeve. [Lake Erie], Sandusky, Erie Co., Ohio (1.2×).
- Fig. 2. *V. malleatus* Reeve. Shiner Pond, Menlo Park, Middlesex Co., New Jersey (1.2×).
- Fig. 3. *Paludina japonica* von Martens (= *V. japonicus* (von Martens)). [Japan]. Lectotype, RVNH 50149 (1.0×).
- Fig. 4. *V. japonicus* (von Martens). Spark's Park, Jackson, Jackson Co., Michigan (1.2×).
- Fig. 5. *V. bermondianus* (d'Orbigny). San Francisco, Cienega de Zapata, Las Villas Province, Cuba (1.9×).
- Fig. 6. *Paludina japonica* von Martens (= *V. japonicus* (von Martens)). [Japan]. Syntype, RVNH 50150 (1.0×).
- Fig. 7. *V. japonicus* (von Martens). Concord River, Concord, Middlesex Co., Massachusetts (1.2×).

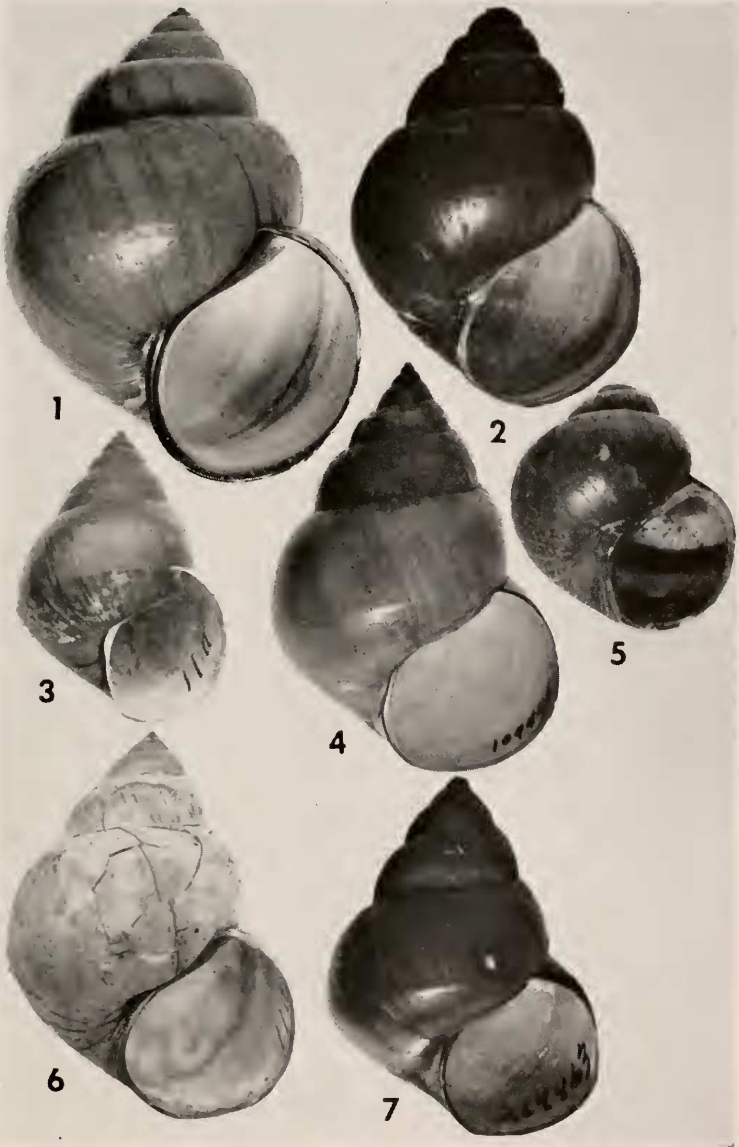


Plate 66

*Remarks.* The original and unillustrated description of *Paludina japonica* by von Martens in 1861 cites a specimen measuring 54 mm. in length by 42 mm. in breadth; mention is made in his remarks of a second specimen with the respective dimensions of 51 and 40 mm., which he considers to be the same species. In both cases this means a height:width ratio of about 4:3, which indicates a degree of globosity roughly equal to that of the more globose specimens of *V. chinensis malleatus* which we have seen. We figure on Plate 66 two specimens from the type lot of *P. japonica* in the Leiden Museum. These are globose and they are also carinate. We here select no. 50149 of the Leiden Museum as the lectotype of *P. japonica*, as this specimen fits most closely von Marten's original description. Number 50150 of that institution includes the paratypes.

*V. japonicus* can be distinguished from *V. malleatus* by having a more acute spire and by having fine carina or carinae. However, we possess individuals of *malleatus* with very faint malleations (see Plate 66, fig. 2), and of *V. japonicus* with a total lack of any carinae (see Plate 66, fig. 4).

Both of these Oriental species which have been introduced into North America may be distinguished from our native species by their larger size and their complete lack of banding at any stage of growth. Small, depressed, dark specimens of either species might be mistaken for *V. intertextus* Say, but the nearly globose shape of the latter species is a consistent and reliable character.

*Specimens examined.* MISSISSIPPI RIVER SYSTEM. OKLAHOMA. Ardmore Mountain Lake, Ardmore, Carter Co.; Stillwater, Payne Co. (both MCZ). GREAT LAKES-ST. LAWRENCE RIVER SYSTEM. MICHIGAN: Spark's Park, Jackson Jackson Co. (MCZ). MERRIMACK RIVER SYSTEM. MASSACHUSETTS: Concord River, Concord, Middlesex Co. (MCZ).

### **Viviparus (Cipangopaludina) chinensis malleatus**

(Reeve)

Plate 66, figs. 1-2

*Paludina malleata* Reeve 1863, Conchologia Iconica **14: Paludina**, pl. 5, fig. 25 (Japan).

*Description.* Shell globose in outline, with some variation in size, large specimens reaching some 60 mm. (about 2¼ inches)

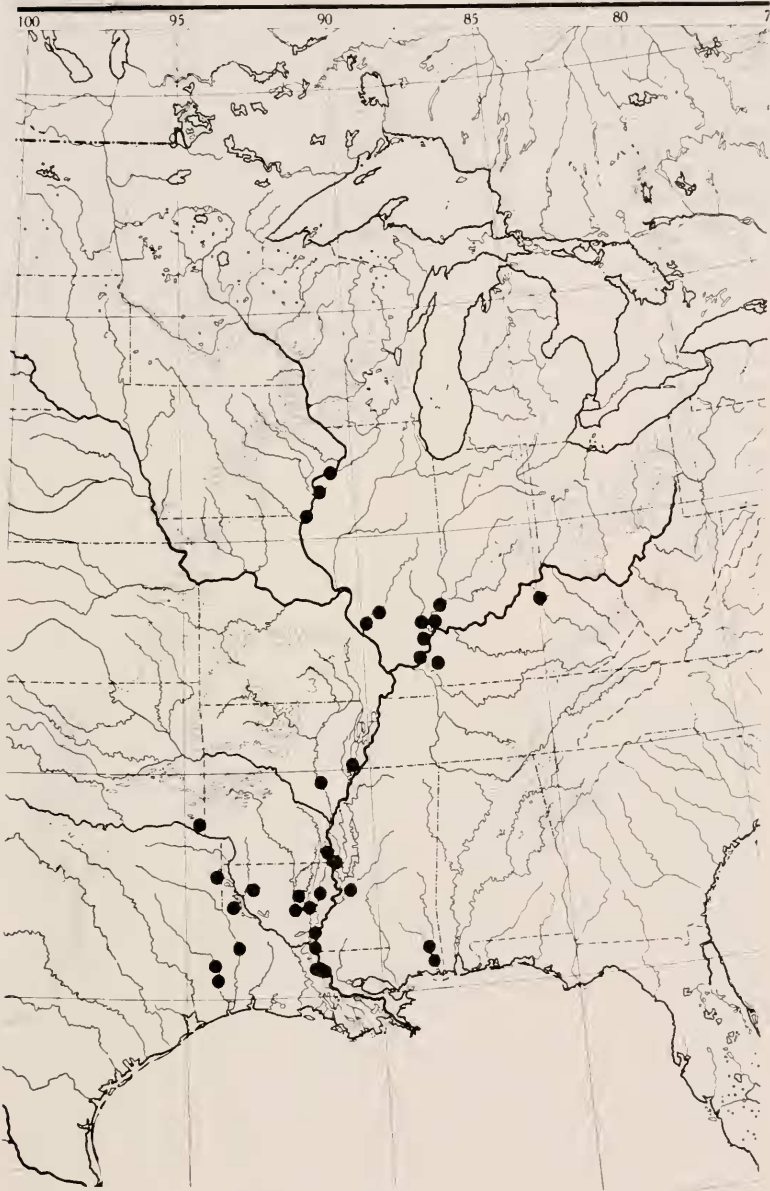


Plate 67  
Distribution of *Viviparus subpurpureus* (Say).

in length, with a small, round umbilicus, covered in part by the reflected parietal lip. Thin in structure, rather strong and smooth. Color a uniform light to dark olive-green, without any bands. Whorls 6 to 7, strongly convex, and generally with a very slight shoulder. Spire moderately extended and produced at an angle of  $65^{\circ}$  to  $70^{\circ}$ . Aperture subovate and virtually holostomatous. Outer lip very slightly reflected; parietal lip slightly reflected and thickened, especially over the umbilical area. Entire lip and a short distance within the aperture colored black. Columella narrow and arched. Suture deeply indented. Sculpture consisting of fine growth lines, spiral lines, and fine to moderate malleation over the entire surface. Occasional specimens will show older reflected lips as fairly strong axial ridges. Others may have one or more spiral threads developed into slight carinae. Operculum corneous, thin, with concentric growth lines and a submarginal nucleus.

length	width	
60.0 mm.	41.0 mm.	Nannacatucket River, Hamilton, Washington Co., Rhode Island
55.0	43.0	Peacock Pond, Lexington, Middlesex Co., Massachusetts
41.5	32.0	Agneu, Santa Clara Co., California
54.0	40.0	Lake Erie, Sandusky, Erie Co., Ohio

The first record for an introduced oriental *Viviparus* in North America is that of Wood (1892); in that year, he purchased a few live specimens in a Chinese market in San Francisco, which were determined as *Paludina japonica* von Martens but were later considered to be *malleatus* by Stearns (1901). Stearns further reports that he was sent some specimens of *Viviparus* from San José, California, where they had been introduced. Hannibal (1911) notes that the species soon became abundant in the so-called "Artesian Belt" between San José and San Francisco Bay. He further records that he personally collected *japonicus* at Hanford, California, in a dry irrigation ditch. He takes care to distinguish his specimens from *malleatus*, since earlier writers had disputed the exact identity of the original *Viviparus* introductions. We have not seen any of this material, but we consider it safe to presume that Hannibal's is the first credible record for the introduction of *japonicus* into North America. Similarly, we may trust Hannibal's determination of Wood's specimens, whereby it is verified that *mallea-*

*tus* first appeared on this continent in 1892. The identity of the *Viviparus* reported by Taylor from Victoria, British Columbia, as noted by Pilsbry (1894), who apparently did not see the specimens, must remain clouded.

Thus, by the turn of the century, species of oriental *Viviparus* were securely established on the North American west coast. In 1914, a collection of *malleatus* was made by the senior author in Muddy River within the city limits of Boston (Johnson, 1915). Again, Johnson (1918), reported this species from Lake Quinsigamond, Worcester, Worcester Co., Massachusetts. Since that time *malleatus* has spread widely in eastern Massachusetts and has appeared in various other eastern localities. At present, the species is to be found in many suitable sites throughout most of central, far western, and eastern United States.

The animal prefers quiet water, either in slow-moving streams or in ponds and lake margins, where there is some vegetation and a substrate of mud.

See also *Remarks* under *V. japonicus*.

*Specimens examined.* (All MCZ.) HAWAII: Halawa Valley, Molokai.<sup>1</sup> WASHINGTON: Green Lake, Seattle, King Co. CALIFORNIA: Suisan City, Solano Co.; Stockton, San Joaquin Co.; Nigger Jack Slough, N of Marysville, Yuba Co.; San José; Agneu; fishpond, Stanford University, all Santa Clara Co.; Quinto Creek, Merced Co.; Santa Barbara, Santa Barbara Co.; Exposition Park, Los Angeles, Los Angeles Co. UTAH: Warm Springs, 4 mi. E of Goshen, Utah Co. ARIZONA: pond, University of Arizona, Tucson, Pimah Co. COLORADO: Radium Hot Springs, Ouray, Ouray Co. TEXAS: pond, Waco, McLennan Co. MICHIGAN: Kalamazoo River, 2 mi. W of Albion and near Marengo, both Calhoun Co.; Red Cedar River, East Lansing, Ingham Co. INDIANA: Mishawaka, St. Joseph Co. OHIO: East End Cove, Lake Erie, Sandusky, Erie Co.; Cleveland, Cuyahoga Co. FLORIDA: Lake Morton, Lakeland, Polk Co.; Mirror Lake, St. Petersburg, Pineilas Co. NORTH CAROLINA: Greenville, Pitt Co. PENNSYLVANIA: Herr's Icepond, Lancaster, Lancaster

<sup>1</sup> In the case of *V. chinensis malleatus* Reeve we eliminate the caption RIVER SYSTEM as so many records are based upon a single locality in any one system.

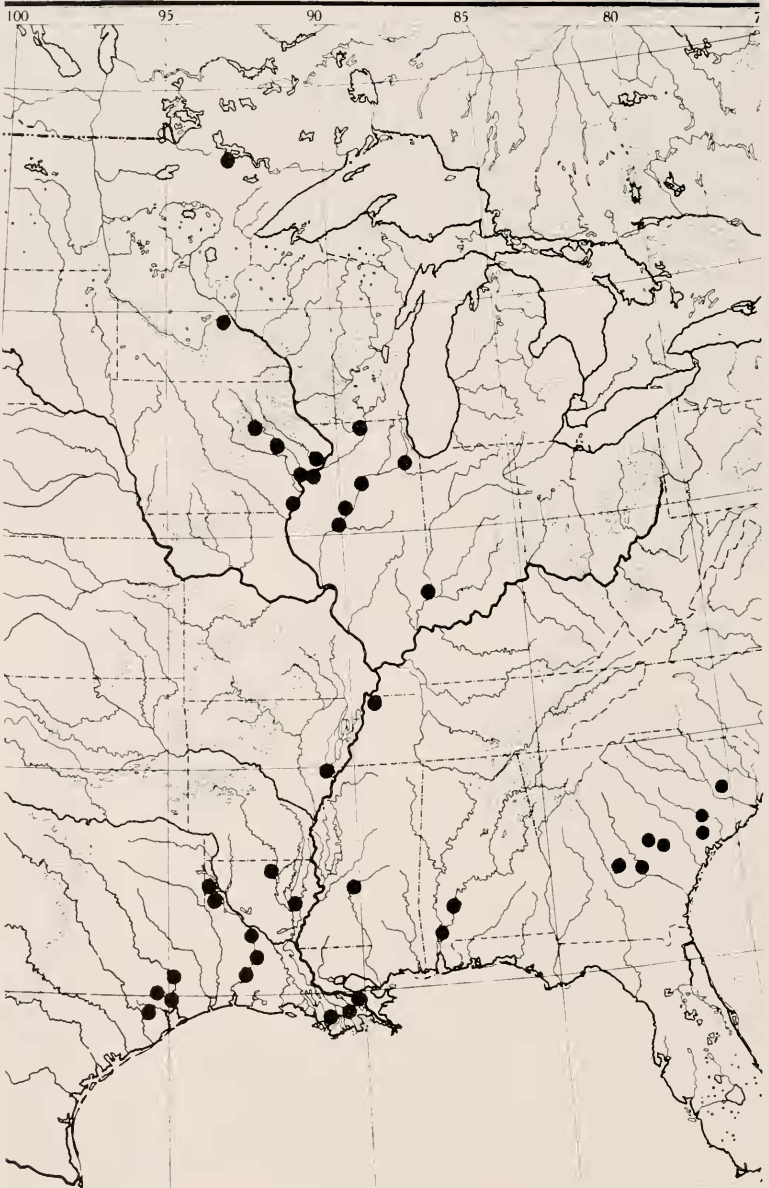


Plate 68  
Distribution of *Viviparus intertextus* (Say).



Co.; Lake Duffy, near Mt. Cretna, Lebanon, Lebanon Co.; pond, Haverford College, Delaware Co. DELAWARE: Silver Lake, Milford, Sussex Co. NEW JERSEY: Raritan Canal, Princeton, Mercer Co.; Shiner Park, Menlo Park, Middlesex Co.; Old Reservoir, Arlington, Hudson Co. NEW YORK: Saw Mill River, Nepera Park, Yonkers, Westchester Co.; Goshen, Orange Co.; Bahnet's Pond, Poughkeepsie, Dutchess Co.; Queens Village, Queens Co.; Freeport, Nassau Co. VERMONT: Lake Fairlee, Thetford Center, Orange Co.; Ottauquechee River, Quechee, Windsor Co. RHODE ISLAND: Nannacatucket River, Hamilton, Washington Co. MASSACHUSETTS: Lake Quinsigamond, Worcester, Worcester Co.; Whitman's Pond, East Weymouth, Norfolk Co.; Pine Tree Brook and pond, both Blue Hills Reservation, Turner's Pond, all Milton, Norfolk Co.; Leverett Pond, Jamaica Pond and Muddy River, all Boston, Suffolk Co.; Hawes Pond, Brookline and Trout Brook, 1 mi. S of Dover, both Norfolk Co.; Peacock Pond, Lexington; pond, Mt. Hood, Melrose, both Middlesex Co.; Pillings Pond, Lynnfield, Essex Co. MAINE: Messalonskee River, Waterville, Kennebec Co.

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